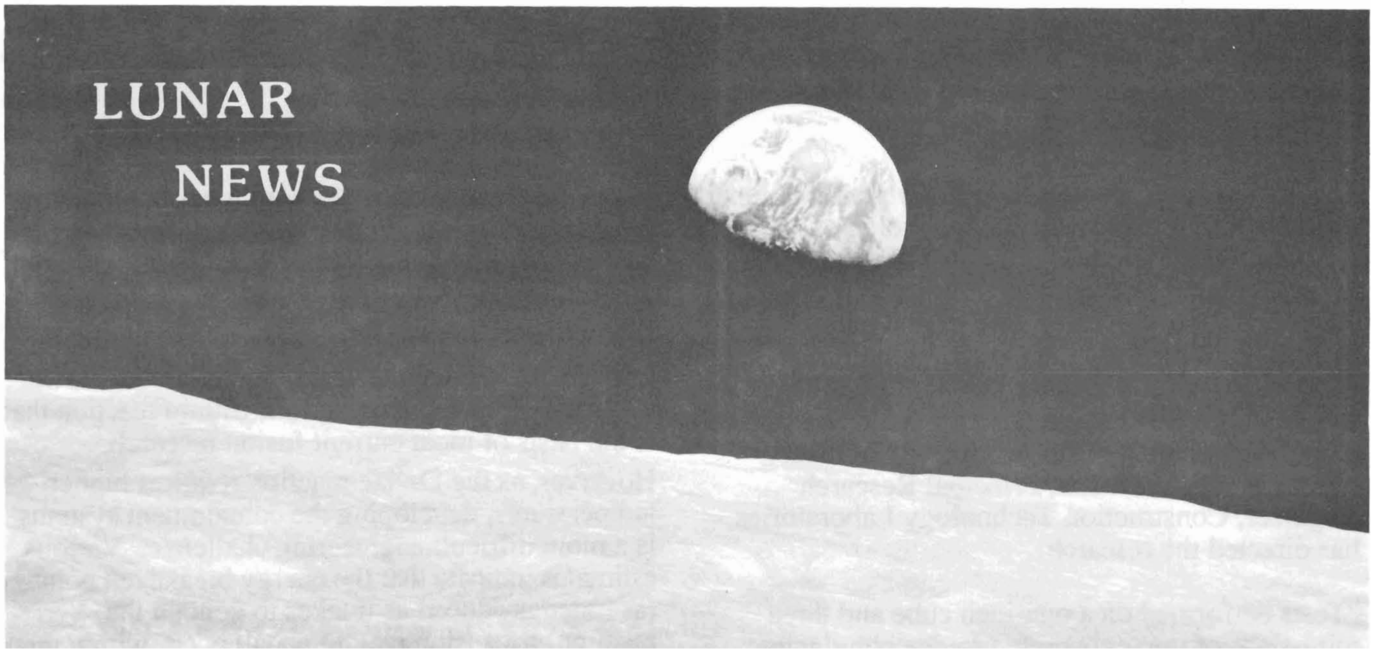

SYMPOSIUM ON LUNAR SCIENCE AND FUTURE EXPLORATION AT 18TH LPSC

Marilyn Lindstrom

A symposium entitled "Lunar Science and Future Exploration" will be held at the Eighteenth Lunar and Planetary Science Conference. The symposium will focus on the Lunar Geoscience Observer (LGO) mission and its contributions to lunar science. The symposium will begin with an overview of the LGO mission that discusses its importance and describes the capabilities of its suggested instruments. A panel of scientists responsible for instrument design will be available to answer detailed questions on instrument capabilities. Four invited talks will focus on major unsolved problems in lunar science and suggest how results from LGO may contribute to their solution. A talk on Lunar Origins will describe models of the Moon's origin and show how new geochemical and geophysical data can constrain them. A talk on Crustal Evolution will discuss the Magma Ocean hypothesis of early lunar differentiation and models of crustal thickness and density; it will also address the later magmatic history of both highland and mare areas. A talk on Surface Processes will discuss regolith processes, cratering mechanics and basin ejecta deposits in an attempt to evaluate compositional effects of impact processes. A talk on Interior Properties will show how measurements of lunar magnetism, electrical conductivity, gravity, and heat flow will constrain models of thermal history and core formation. The remainder of the symposium is reserved for contributed talks on scientific problems which may be addressed with new data from LGO or other future lunar missions. Abstracts of talks should be submitted to the 18th Lunar and Planetary Science Conference specifying "LGO Symposium."

LUNAR NEWS NO. 47 FALL 1986

LUNAR CONCRETE

T. D. Lin

Testing has been completed on forty grams of lunar soil allocated to Construction Technology Laboratories in Skokie, Illinois. The size of the sample awarded by the National Aeronautics and Space Administration was one of the largest given to a researcher to date. The lunar soil sample was earmarked for tests to determine its suitability as an aggregate for making concrete on the Moon, and to obtain data on the physical properties of lunar concrete. Dr. T. D. Lin, Principal Research Engineer, Construction Technology Laboratories, has directed the research.

"Tests performed on a one-inch cube and three mini-slabs of lunar concrete provide convincing evidence that lunar material will be ideal for building concrete structures on the Moon," stated Dr. Lin. The tests conducted included specific gravity, bulk density, examination by scanning electron microscope, electron microprobe analysis, petrographic analysis, modulus of elasticity, modulus of rupture, thermal coefficient of expansion, and compressive strength.

Tests conducted to determine the compressive strength of the lunar concrete, a fundamental measure of the quality of the material, showed that strengths in excess of 10,000 psi could be obtained with the lunar materials. "This is comparable to high-quality concretes produced with earth materials," stated Dr. Lin.

"Concrete has many material and structural merits for the proposed lunar-base construction. An obvious advantage is that most of the components of the concrete can be produced simply from lunar materials. Perhaps concrete will provide the ultimate solution to outer-space colonization," Dr. Lin stated.

Construction Technology Laboratories (CTL) is one of the largest and best qualified technological facilities in the world devoted to providing services to the construction industry. Consulting, testing, research, and engineering services are provided on a contract basis. A division of the Portland Cement Association, CTL is located at 5420 Old Orchard Road, Skokie, Illinois 60077.

^{3}He ON THE MOON

Michael B. Duke

Recently, considerable discussion has emerged on the question of mining the Moon for solar wind emplanted ^{3}He for use on Earth in nuclear fusion reactors (Wittenberg et al., Fusion Technology, Vol. 10, No. 2, 1986). A deuterium-^{3}He fusion reactor would have the advantage of a much lower neutron flux than the deuterium-tritium reaction that is the basis of most current fusion research. However, as the D-^{3}He reaction requires higher temperatures, developing the containment systems is a more difficult engineering challenge. Various estimates indicate that the energy breakeven point (as much produced as it takes to contain the reaction) for fusion reactions will occur within the next three to five years. Even if it takes longer to develop the containment for breakeven in the D-^{3}He reaction, the argument is made that the much lower neutron flux will shorten the development time for power reactors, due to the lesser need for shielding and neutron-resistant design.

Even if D-^{3}He reactors existed now, there is not enough ^{3}He on Earth to support widespread use of fusion power. However, helium concentrations in the lunar regolith are about 15 - 20 ppm by weight, of which one part in about 2500 is ^{3}He. The energy recovered from the fusion reaction is so large that the extraction of lunar regolith ^{3}He and its return to Earth is probably small in proportion (1:250, according to Wittenberg et al.), and the total amount of helium in the lunar regolith is immense. The challenge of mining lunar helium is whether small amounts of volatiles can be extracted efficiently from large amounts of regolith. The problem is similar for the extraction of hydrogen and other solar wind species, which would be quite useful for lunar base operations, if they could be extracted efficiently. Should the Moon be mined for ^{3}He, of course, large quantities of the other volatile solar wind species would also become available.

****
****

LUNAR SAMPLE ACTIVITY AS REFLECTED BY ALLOCATIONS IN JUNE 1986

John Dietrich

The Lunar and Planetary Sample Team (LAPST) reviewed lunar sample requests from seven investigators at its June 16-18 meeting and recommended allocating 130 samples (weighing 16.09 grams) and one thin section to six investigators. Following review of two requests from the JSC Public Affairs Office for samples mounted in glass display cases for long-term displays at major museums, LAPST identified two samples (weighing 341.00 grams) for the displays.

LAPST also reviewed and endorsed the Curator's allocation of 21 samples (weighing 0.84 gram) and 27 thin sections to three investigators who requested samples between the February and June meetings.

Two requests for samples from the double drive tube 79001/79002 account for the largest number of samples. Preliminary evaluation studies require a small sample from each dissection interval along the core. The FMR profile of 79002, published in this issue of Lunar News, is based on data from these studies. Larger samples, from locations identified after each FMR profile is available, will be sieved and each size fraction analyzed petrographically and for rare gas. Another investigator will study the nature, distribution, and isotopic signature of the implanted gas component of soil from the core.

The recommended allocations will support two isotopic studies. Six samples from the Apollo 15, 16, and 17 collections will be analyzed as part of an important study to determine the isotopic composition of lunar primative lead. Another investigator will determine the isotopic composition of carbon in a sample of lunar soil.

Consortium studies of two Apollo 14 breccias generated a request for the excavation of specific clasts for petrographic study and INAA. The clasts were identified during studies of the rock surfaces in the Lunar Sample Laboratory.

Other recommended allocations support studies of:

- coexisting mineral polymorphs
- datable lunar zircons
- KREEP basalts
- petrologic diversity of pristine lunar rocks

Two requests for long-term displays account for most of the sample mass allocated at the June meeting. Basalt samples from the Apollo 15 and Apollo 17 collections will be mounted in glass display cases and allocated to the JSC Public Affairs Office. These samples will be assigned to major museums in the United States as long-term displays.

LAPST recommended denial of the request from one investigator.

****
****

18th LPSC ANNOUNCEMENT

The 18th Lunar and Planetary Science Conference will be held March 16-20, 1987, at the NASA Johnson Space Center, Houston, Texas. Inquiries and further information can be obtained from the LPI Projects Office (713-486-2150) or the LPI Publications Office (713-486-2143) or by writing to the 18th LPSC -- Attn: Pamela Jones, Lunar and Planetary Institute, 3303 NASA Rd. 1, Houston, Texas 77058-4399.

"Lunar News" is produced three times a year by the Planetary Materials Branch of the Solar System Exploration Division, Johnson Space Center of the National Aeronautics and Space Administration. "Lunar News" is intended to be a forum for discussion of facts and opinions regarding lunar sample study, Lunar Geochemical Orbiter and Lunar Base activities. It is sent free to a mailing list of more than 700 individuals; to be included on the mailing list, write to the address below. Your contributions to "Lunar News" on topics relating to the study, exploration and utilization of the Moon and comments about "Lunar News" and material appearing in it should be sent to:

Doug Blanchard, Lunar Sample Curator
Code SN2, NASA JSC
Houston, TX 77058

REPORT ON THE FeO AND I_s/FeO PROFILES FOR LUNAR CORE 79002

Dick Morris

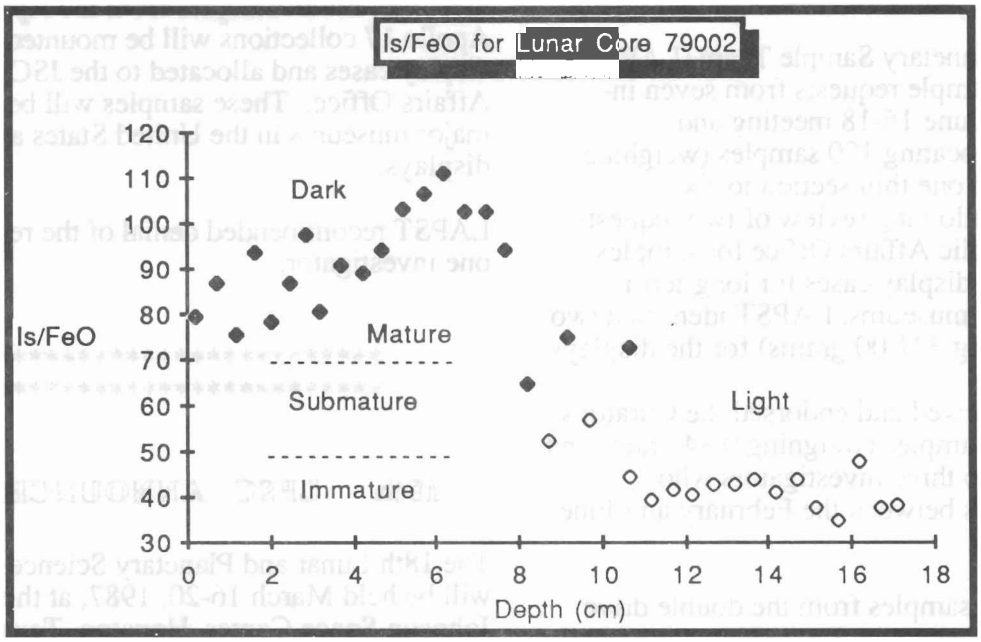

Figure 1. Exposure index shows distinct break at the light-dark boundary in lunar core 79002. The dark materials are distinctly more mature than the underlying light materials.

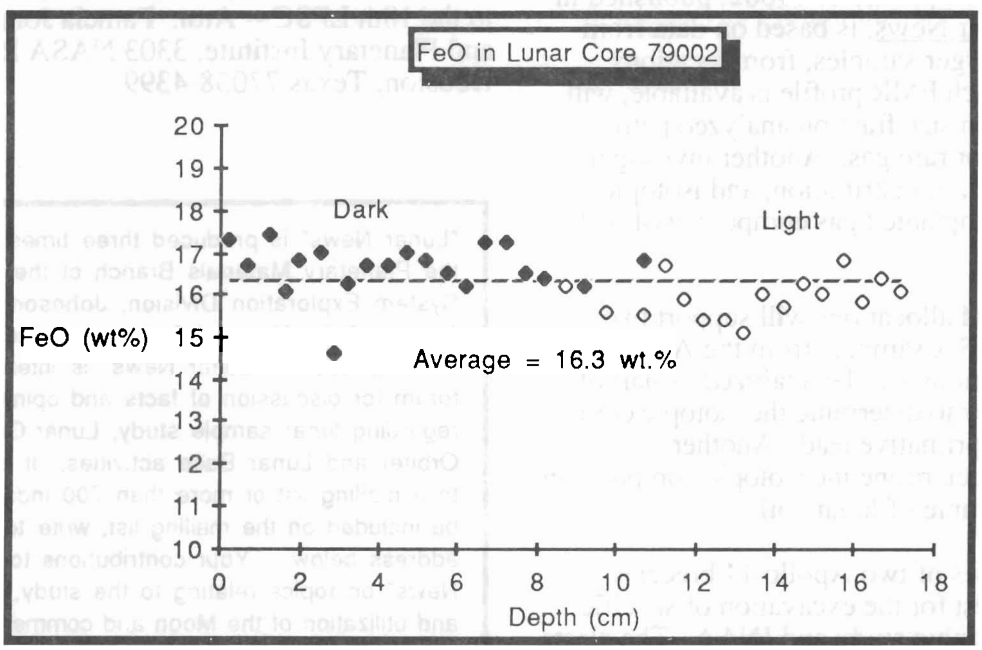

Figure 2. The FeO contents of soils from the 79002 core are nearly constant throughout the length of the core. Both light and dark materials have very similar FeO contents. The analyses were done by Richard V. Morris in the Ferromagnetic Resonance Laboratory of the JSC Solar System Exploration Division. For more information, you may write or call Dick at (713) 483-5874.

NEWLY-OPENED APOLLO 17 CORE REVEALS DARK/LIGHT CONTACT

Carol Schwarz

The 79002/79001 double drive tube was collected at Station 9, about 70 m south of Van Serg Crater, a 90 m crater just south of the North Massif and the Sculptured Hills in the Taurus Littrow Valley (Fig. 1). The upper section, 79002, was extruded in June and preliminary information is now available.

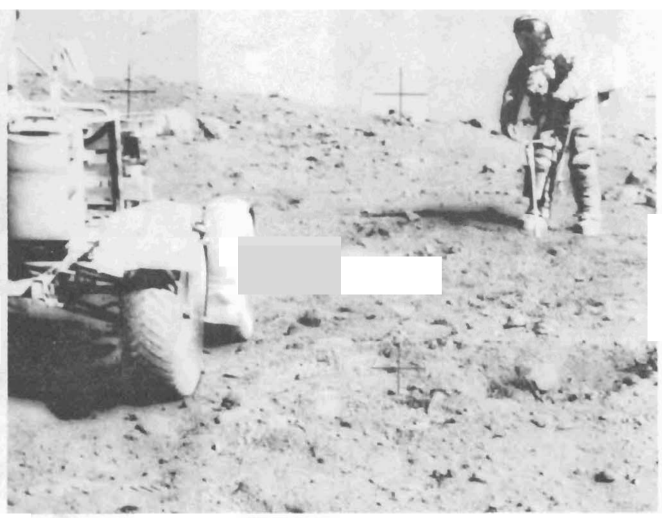

Figure 1. Collection of soil core 79002/1 at Station 9, Apollo 17. Trench soil samples 79220, 79240, 79260 were taken within one meter of this core. (NASA photo AS-17-143-21837.)

X-rays of the core taken in 1975 show that the core was about 19.4 cm in length. Actual length after extrusion was 17.4 cm, a decrease of 2 cm. A small void, observed throughout the length of the core tube before extrusion, was still present from the top to about 8 cm after extrusion.

Following extrusion, the outer 1-2 mm rind was removed revealing a distinct light-dark boundary inclined 25 to 30 degrees from 8.5 to 11 cm below the surface. Dissection of this first layer was done in 0.5 cm increments starting at the top. The soil in each interval was placed on a 1 mm sieve to separate the soil into coarse and fine fractions. The coarse particles were separated into various types including basalts, breccias, glass, and light colored, possibly plagioclase-rich, particles. Since all fragments were extremely dust covered, determination of their types was difficult and uncertain. Figure 2 summarizes the data in the two groups, the dark and the light portions. Data from the transition zone of dark to light was omitted.

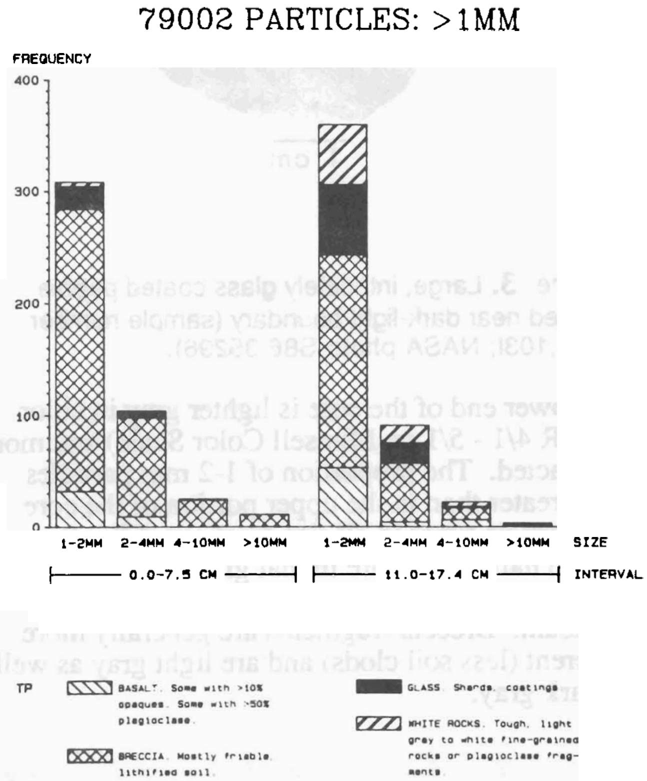

Figure 2. Preliminary observations of particle types, removed from first dissection pass, indicate distinct populations.

The upper portion of the core is dark gray (10 YR 3/1 on Munsell Color Scale) and loosely packed. Soil breccias and soil clods are the dominant type in all size ranges. A few tough, dark matrix breccias and breccia particles partially coated by shiny black glass were included with the soil breccias. Basalt and glass particles, found in the smaller size ranges, were much less abundant. Several large particles (some up to 2 cm) were excavated and nearly all were friable soil clods, some with glass. In the dark material near the dark-light boundary, a large 3 cm pebble and two smaller pebbles were uncovered. The largest pebble was removed and dusted (Fig. 3). It is irregularly shaped and partially covered with dusty glass which forms two pointed edges at one end. <1 mm vesicles are abundant on its surface. This pebble is probably a breccia.

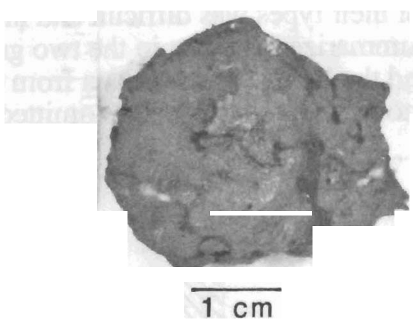

Figure 3. Large, intricately glass coated pebble removed near dark-light boundary (sample number 79002,103l; NASA photo S86-35296).

The lower end of the core is lighter gray in color (10 YR 4/1 - 5/1 on Munsell Color Scale) and more compacted. The proportion of 1-2 mm particles was greater than in the upper portion of the core. The particle types in all size fractions differ from the top half of the core in that glass, basalt, and the light colored fragments are noticeably more abundant. Breccia fragments are generally more coherent (less soil clods) and are light gray as well as dark gray.

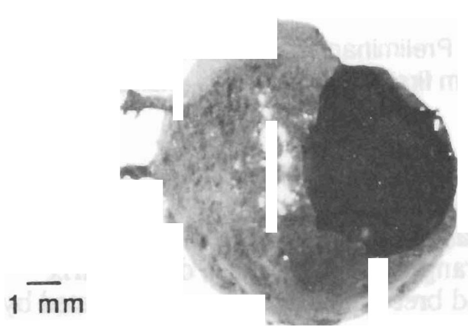

Figure 4. Thin walled glass bubble with protruding glass strands (sample number 79002, 2018).

The chemically pure second pass was recently completed. This time, each 0.5 cm increment of soil was scooped directly into a container, omitting the sieving, to keep handling of the samples to a minimum. This layer seemed to contain more large glass particles, especially in the dark portion, in a variety of sizes and shapes. Two hollow glass bubbles, both about 7 mm in diameter and both incomplete enclosures, were exposed. One is extremely thin walled and has a shiny black interior. Two thin strands of glass protrude from the exterior surface of the bubble (Fig. 4). The other is slightly elongated and extremely dusty with a small triangular shaped hole. A concentration of about six pebbles, 1 to 2.5 cm in diameter, were uncovered near the light-dark boundary, in the same area as the 3 cm particle was located (Fig. 5).

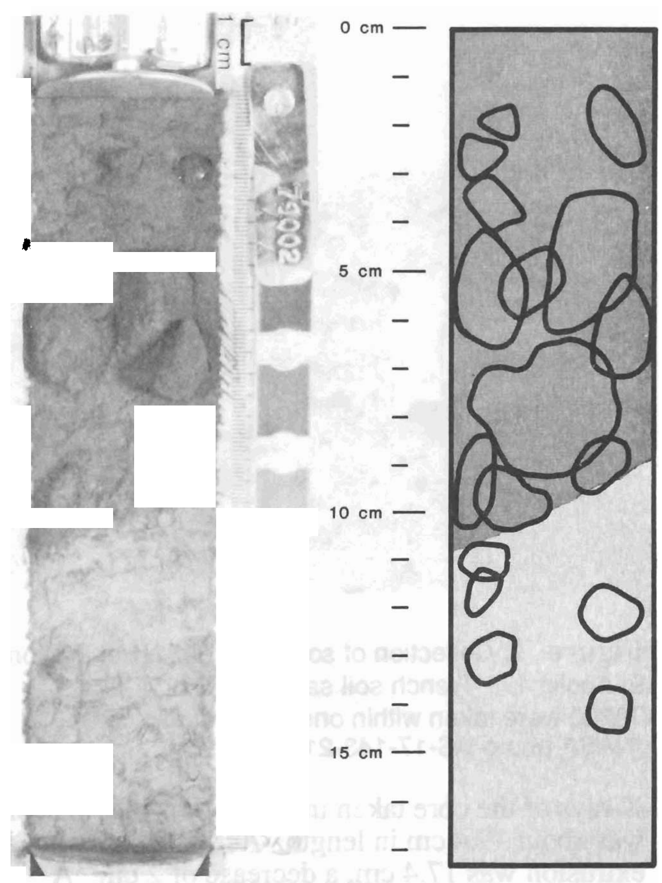

Figure 5. Photograph of core after second dissection pass. Note dark-light boundary. Drawing shows location of largest rocks encountered during two dissection passes. (NASA photo S86-36040.)

Dissection of the third layer is in progress at this time. Another interesting glass object has been excavated. It is oval shaped and weighs 0.86 g with dimensions of about 1.2 x 1 x 1 cm. It consists of shiny black glass with scattered areas having a metallic luster. About 75% of the object is covered with dark fine grained soil. The surface is irregular with a number of glassy protrusions (Fig. 6). There is a tiny opening (<1 mm) on its surface, but it is not large enough to determine whether or not this object is hollow.

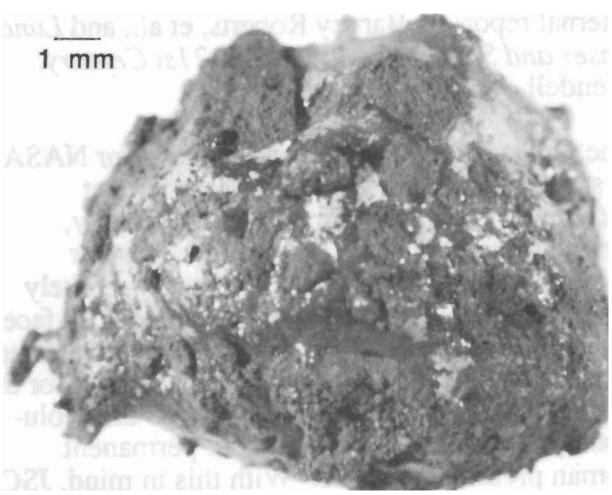

Figure 6. Glassy object with scattered areas of metallic luster (sample number 79002, 2030).

****
****

LUNAR INITIATIVE RESPONSE TO THE NATIONAL COMMISSION ON SPACE REPORT

Kyle Fairchild
Advanced Programs Office
NASA-JSC

The National Commission on Space was appointed by the President and charged by Congress to formulate a bold agenda to take America's civilian space program well into the 21st century. The Commission recently concluded its year long study and has published its findings in the book *Pioneering the Space Frontier* (Bantam Books, May 1986). The report outlines the steps the nation should take for scientific inquiry, exploration, and enterprise that will lead to the first human outposts on the Moon by 2005 and Mars by 2015. Specifically, the 15-member Commission feels the United States should adopt an aggressive plan:

> "To lead the **exploration** and development of the space frontier, advancing **science**, **technology**, and **enterprise**, and building institutions and systems that make accessible vast new resources and support **human settlements** beyond Earth orbit, from the highlands of the Moon to the plains of Mars."

The Commission feels this effort should be focused into three mutually supportive thrusts:

- Advancing our understanding of our planet, the solar system, and the universe;
- Exploring, prospecting, and settling the solar system; and
- Stimulating space enterprises for the direct benefit of the people on Earth.

Recognizing the problems of future space endeavors will be as much economic as technical; the Commission proposes two additional thrusts to provide economic viability:

- Advancing technology across a broad spectrum to assure timely availability of critical capabilities; and
- Creating and operating systems and institutions to provide low cost access to the space frontier.

The Moon figures prominently in the Commission's recommendations. The economic arguments of lunar derived resources delivered to high Earth orbit using less than 1/20th of the energy required to deliver an equivalent amount of mass from the surface of the Earth, are pretty persuasive. Lunar activities would begin with robotic prospector missions to discover and characterize usable lunar materials, with particular emphasis on searching for volatiles that may be frozen near the lunar poles. Sample return missions would bring back material from those areas possessing the most valuable chemical elements, to characterize minerals and initiate industrial process development, based on their physical and chemical properties. Automated roving vehicles, teleoperated from Earth, would then carry out further exploration and surveying, to be followed by astronaut crews to establish the first "lineshack" type outposts. Finally, closed ecology life support habitats would be created to support permanent human presence at the lunar base. In addition to supplying resources to promote further expansion into space, the lunar base will be used for technology development and testing, as well as a multitude of scientific endeavors. including farside astronomy (the only place in the universe that never has to "listen" to the Earth).

To maintain the Earth-Moon space infrastructure, the lunar base, and the eventual Mars base, the Commission envisions an evolutionary network of space stations or spaceports: near-Earth, orbiting the Moon and Mars, in the Earth-Moon libration point L1, and in periodic orbit between the Earth and Mars. The evolutionary approach to space development, building on the technology and infrastructure that has already been developed, can be done with reasonable budget levels in an expanding economy. The Commission foresees the funding investments required for its agenda should stay less than half (as a percent of the GNP) of U.S. space investments during the peak Apollo years.

The report has been given to the President and both Houses of Congress. The President has tasked Senior Interagency Group for Space (SIG/Space) to prepare a response within 60 days that is sensitive to all aspects of national space policy: civil, military, and commercial. Each House of Congress has included stipulations in their appropriation bills that require NASA to implement the recommendations of the Commission. The National Aeronautics and Space Council, created by the original NASA Space Act, has also been reestablished, as recommended by the Commission. In addition, NASA Headquarters has created an internal ad hoc committee to prepare an implementation plan that will be given to the President on December 31, 1986.

In the meantime, the Johnson Space Center, as part of the lunar initiative, is actively pursuing recommendations of the Commission. The lunar base computer modeling effort is entering its second year, with support from the Large Scale Programs Institute, Systems Development Corporation, Earth Space Operations, and numerous other government, academia and industry participants. Work is being completed on Missions and Opportunities of a Lunar Base. This missions data base containing trades and issues related to lunar enterprises will be available soon.

A Request for Proposals (RFP) has been released to develop preliminary designs of the Lunar Base Surface Systems. Designs will include Life Critical Systems, Science and Exploration Systems, Permanent Mission Support Systems, and Lunar Resources Utilization Facilities. This effort will be based on previous lunar base studies, particularly "Lunar Surface Return," a 1984 JSC internal report by Barney Roberts, et al., and *Lunar Bases and Space Activities of the 21st Century,* Mendell, W. W., ed.

The Commission made a strong appeal for NASA to search out partners in space development activities, both internationally and nationally, among private industry, academia, and other government agencies. It is exceedingly unlikely that NASA will be directly responsible for all facets of 21st century space activities. Public/private and international ventures offer the best potential for the sustained, committed effort needed for the evolutionary, long term development of permanent human presence in space. With this in mind, JSC, the Jet Propulsion Laboratory, and Los Alamos National Labs are sponsoring a workshop to bring together representatives from industry, academia, and other government agencies to discuss how we all might work together as equal partners in space development. We will be talking with companies that represent the bulk of American industry and are interested in extrapolating their terrestrial experience in mining, manufacturing, construction, etc., into the space and planetary environment. The focus of this workshop will be the in situ resources utilization on the Moon, Mars, and free space. Primary emphasis will be on the Moon, since we know the most about it, and it offers the most near term application of these technologies. With the evolutionary approach, however, the technologies that will be developed will have immediate applications to Mars and beyond.

****
****

U. S. GOVERNMENT PRINTING OFFICE 1987-761-013/40407